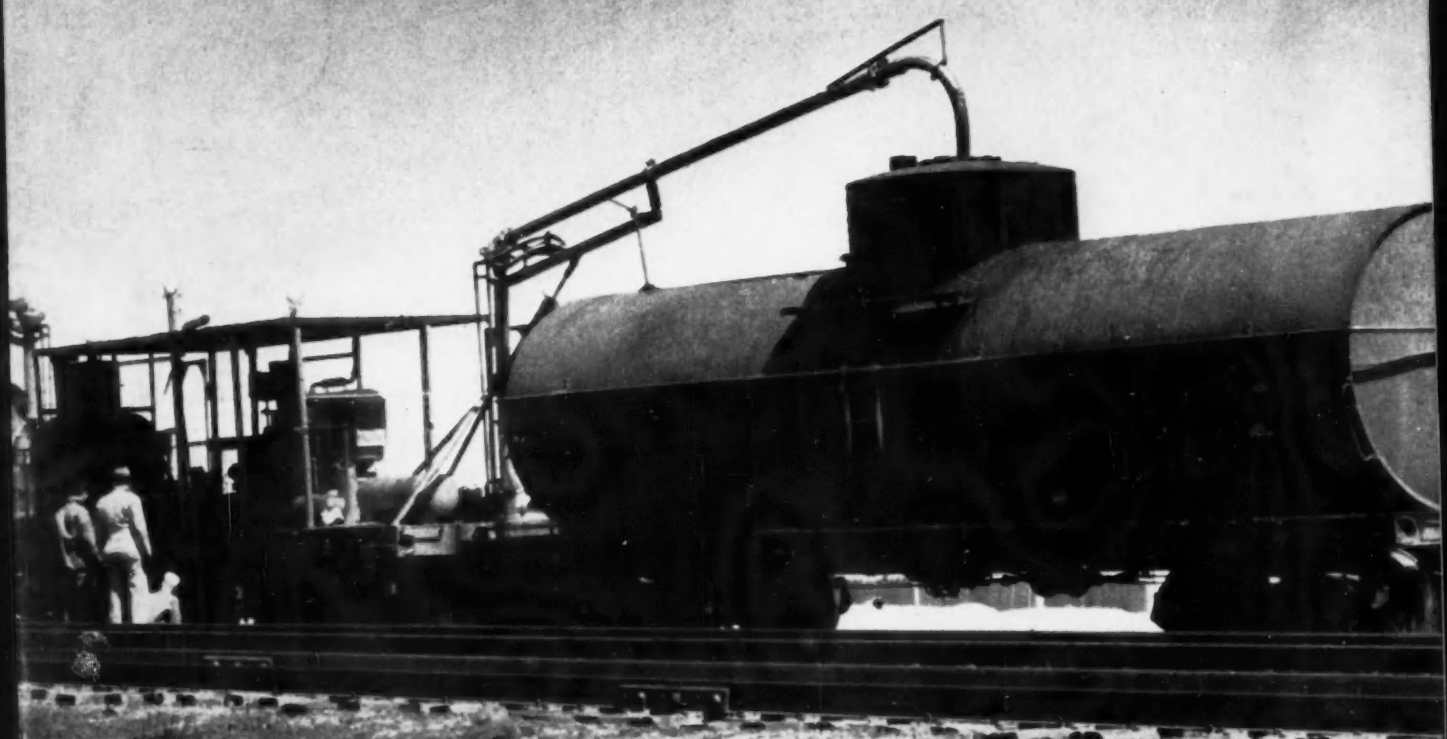
ASPHALT INSTITUTE *Quarterly*

JULY, 1959



In this issue:

ASPHALT-TREATED RAILROAD BALLAST

PUBLICATIONS of the ASPHALT INSTITUTE

•

MANUALS

***Thickness Design, Asphalt Pavement Structures for Streets and Highways*, M.S. 1**

A complete text describing the proper control and operation of both continuous and batch type asphalt plants.

***Mix Design Methods for Hot-Mix Asphalt Paving*, M.S. 2**

This text contains the latest data for the design of hot-mix paving mixtures. Four methods are outlined.

***Asphalt Plant Manual*, M.S. 3**

Step-by-step methods for determining thickness requirements for light, medium, and heavy-duty asphalt roads.

***Asphalt Handbook*, M.S. 4**

As its title implies, this is a handbook on asphalt —what it is, how it is tested, what it is used for.

***Introduction to Asphalt*, M.S. 5**

Chapters I through IV of M.S. 4 comprise this text and includes uses, history, definitions, tests.

***Asphalt Pocketbook of Useful Information*, M.S. 6**

In vest pocket size, 104 pages of tables and miscellaneous data most used in asphalt construction.

•

SPECIFICATIONS

***Specifications and Construction Methods for Hot-Mix Asphalt Paving for Streets and Highways*, S.S. 1**

Together in concise, logical relationship are all recognized and proven types of hot-mix asphalt paving.

***Specifications for Asphalt Cements and Liquid Asphalts*, S.S. 2**

Contained under one cover are all currently approved specifications for asphalt cements, liquid asphalts.

***Specifications and Construction Methods for Asphalt Curbs and Gutters*, S.S. 3 (I.S. 92)**

Dual-purpose booklet combines general information with building data and approved FHA specifications.

***Construction Specifications*, S.S. 4**

Interim volume contains current specifications for different types of modern asphalt construction.

•

CONSTRUCTION

Asphalt Protective Coatings for Pipelines, C.S. 96

New second edition describes three major classifications of asphalt protective coatings for pipelines.

EDITORIAL

The Importance of Proper Compaction

The accelerated pavement test at Columbus Air Force Base last year was more than a simple vindication of asphalt paving. It was an object lesson in proper construction methods. More than that, it was an exercise in the application of sound judgment and modern construction equipment.

Probably the most significant conclusion that was reached by those closely associated with the test was that full and proper compaction in all courses is the key to a successful modern asphalt pavement. Proof rolling of the subgrade and pavement courses serves the double purpose of increasing the supporting power of the courses and disclosing weak spots which could consolidate further under the additional compaction furnished by traffic.

Certain criteria have been established for adequate subgrade compaction and observance of these criteria is earnestly recommended by The Asphalt Institute. Cohesive materials should be compacted to 95-100 percent of Modified AASHO density in the top twelve inches, and to 90-95 percent below this in fill areas. Where cohesive soils have an optimum moisture near the plastic limit, they should be compacted at a moisture content at least two percent below theoretical optimum moisture.

Cohesionless material should be compacted to a minimum of 100 percent Modified AASHO density in the top twelve inches, and to a minimum of 95 percent below this for all fill areas.

The rapid improvement in compaction equipment and the appearance of new types of equipment demand a reappraisal of traditional methods. The rising popularity of vibrating compactors and pneumatic-tire rollers suggests the need to examine these machines with an eye to determining their most effective use.

It is axiomatic that weight alone tends to give maximum compaction near the surface of the mass being compacted. Kneading action of the pneumatic-type roller tends to increase compaction, and vibration tends to deepen compaction. With this in mind it can readily be seen that each type of roller can be expected to work most effectively within a prescribed range of operation, but a combination of types can be used with maximum effect on each course of an asphalt pavement structure.

With pneumatic-tire compaction, the contact pressure range is the critical factor, bearing in mind that it should exceed the contact pressure of the vehicle tires which will use the pavement. This contact pressure range varies with the size and type of roller tire, and depends also on the wheel load and tire inflation pressure.

It is a demonstrated fact that an asphalt pavement structure adequately compacted in the supporting courses and carefully rolled in the binder and surface courses will not be plagued with settlement or compression problems after exposure to high density traffic. It, therefore, is most important that the subgrade and each course of the pavement structure be properly compacted with suitable equipment.

Asphalt Institute Quarterly

Volume 11, No. 3 **July, 1959**

Glynn Harvey
Editor

•

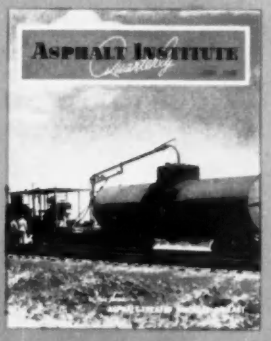
Robert J. Lowe
Assistant Editor

Contents

	PAGE
Editorial: Importance of Compaction	3
Chicago: City of Big Pavements	4
Easy Does It	6
Maumee, Ohio, Solves a Street Problem	
Great Caesar's Ghost	8
Italy's 100-mph "Highway of the Sun"	
The Natchez Trace	11
We've Been Workin' on the Railroad	12
Asphalt Treatment for Ballast	
The Roncevert Road	14
Members and Offices of The Asphalt Institute	15

Cover

Santa Fe work train with new distributor car and specially modified gondola car designed for spreading aggregate cover made initial trial run on the section of track between Victorville and Barstow, Calif.
(See story: Page 12.)

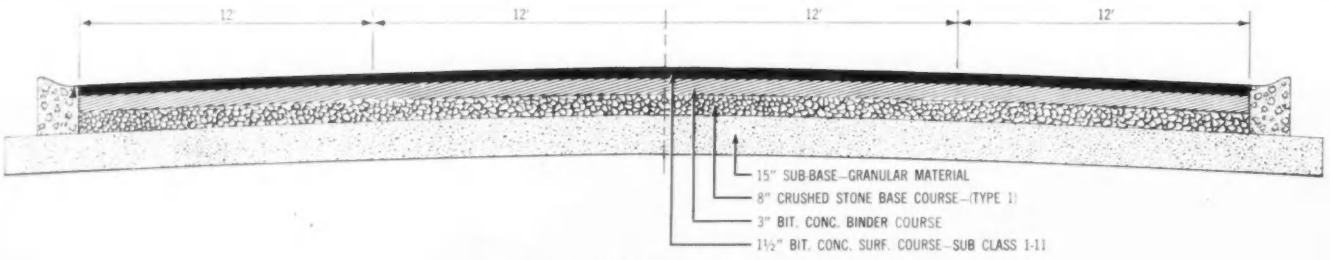


The Asphalt Institute Quarterly is published by the Asphalt Institute, an international, nonprofit association sponsored by members of the petroleum asphalt industry to serve both users and producers of asphaltic materials through programs of engineering, research and education.

The member companies of the Institute, who have made possible the publication of this magazine, are listed on page 15.

•

Articles may be reprinted with credit line. Correspondence should be addressed to the Asphalt Institute Quarterly, Asphalt Institute Building, University of Maryland, College Park, Maryland.



TYPICAL CROSS SECTION OF 48' PAVEMENT

Chicago:

CITY OF BIG PAV

AVEMENTS

Lake Shore Drive Extension an Example of Sound Design

THE POET, Carl Sandburg, is a fast man with a mental image. He described Chicago as the "City of the Big Shoulders."

In terms of highway engineering, Sandburg was just a little wide of the mark. Chicago is building quite a reputation as the "City of Big Pavements."

The northern extension of the asphalt-paved Lake Shore Drive is a case in point. When the Cook County Highway Department in 1953 designed the asphalt pavement for this 1.5-mile stretch of new expressway, the engineers gave it enough muscle to do the job.

BROKE BOTTLENECK

Chicago's 12-gauge Lake Shore Drive has been the salvation of a burly, bustling metropolis that was threatened with strangulation by its own traffic. These twin bands of asphalt paving daily carry over 100,000 vehicles into and out of the downtown commercial center. But the Drive created a brand new traffic bottleneck at its Foster Avenue terminus and, to break this bottleneck, it was decided to extend the expressway north to Hollywood Avenue on land captured from Lake Michigan.

One million cubic yards of fill were used, consisting largely of clay, sand and cinders mixed with broken brick and rubble from building removal and excavation on the Congress Street expressway. It also served as a convenient disposal area for other excavation work in the midtown area.

After the Chicago Park District finished the grading, construction of the pavement was begun with fifteen inches of granular subbase. On this was placed eight inches of stone base, then came three inches of asphalt concrete binder course topped off with 1½ inches of asphalt concrete surface. Total thickness of the asphalt pavement structure was 27½ inches, a sound heavy-duty design. In all, the finished job represented approximately 17,500 tons of asphalt concrete, 28,500 tons of stone base and 54,800 tons of granular base material.

WIDE SHOULDERS

The extension consists of four 12-foot driving lanes in each direction separated by a 30-foot median strip. A continuous stabilized shoulder eleven feet wide on each side of each roadway supports Mr. Sandburg's poetic thesis of "the City of the Big Shoulders" and offers refuge for the distressed motorist.

The performance of the northern extension has lived up to its advance billing. Now five years old, the road, like its parent expressway immediately to the south, is carrying the full burden of Chicago's commuter traffic.

Carl Sandburg's Chicago is more than a hog butcher, wheat stacker and a nation's freight handler. It is also a shrewd street engineer with a special talent for building muscular asphalt pavements.

EASY DOES IT

Pay-As-You-Go Resurfacing Eases Maumee Street Crisis

IN 1954, Maumee, a proud city of 10,000 near Toledo, Ohio was suffering from a monumental case of municipal migraine. Its entire street system was in a magnificent state of decay.

Maumee's network of concrete, brick and sheet asphalt pavements were from twenty to thirty years old. Maintenance costs were astronomical and rising. Several men were employed full time in the summer just removing weed growth.

LITTLE BY LITTLE

An overnight miracle of rehabilitation was out of the question. The cost of such a project was appalling. But the City Council reasoned that the patient would never recover unless treatment was started. So they voted to set aside $20,000 each year and then drew up a work schedule, assigning earliest priority to those streets in poorest condition.

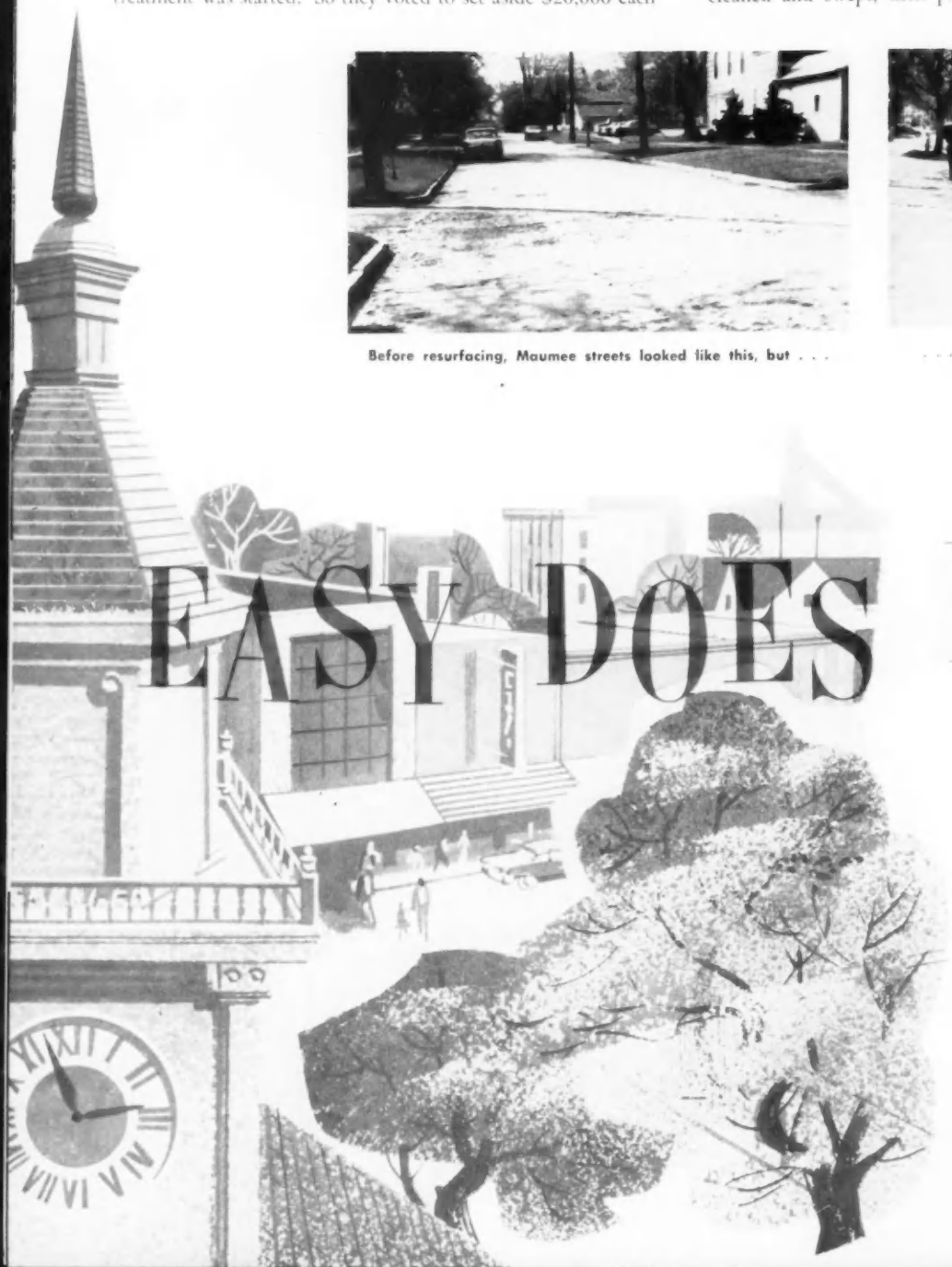
At this point, Maumee's governing body threw the book away and embarked on a program without precedent. Instead of hammering out a close-fitting contract, with completion dates and a schedule of penalties, the city entered into a broad agreement with the contractor. It was agreed that the contractor could work on the resurfacing program at his own convenience. Also, the city tried to group the resurfacing projects for convenience of the contractor.

In return, the happy contractor gave quality workmanship at rock-bottom prices.

In the resurfacing program, the streets selected were first cleaned and swept, then patched. After the city crew com-

Before resurfacing, Maumee streets looked like this, but . . .

. . . block by block, between big contracts . . .



pleted its preliminary work, the contractor moved in and patched out the streets. Then he applied a tack coat, followed by a leveling, or "scratch", coat as needed, and a 1½ inch surface course. The average cost for patching, tack coat and single course resurfacing has been 75 cents per square yard.

The program now has been in operation for four years and approximately 5.8 miles of sadly deteriorated streets have been resurfaced. City officials figure that about two more years' work will finish the job.

MAINTENANCE COSTS CUT

Already maintenance costs have been reduced dramatically; maintenance crews have been freed for other work. Snow removal has been made easier because the plows can work much closer to the smooth new surface than they could on the old rough pavements. Weed growth has ceased to be a problem and cleaning operations are vastly more efficient.

Meanwhile, Maumee's neighbors are watching the transformation with admiration and envy and Maumee's proud citizens are prouder than ever. Traffic moves with silky smoothness, the city looks cleaner and brisker, and Maumee householders are delighted with the new hush that has settled on its streets.

As one taxpayer enthusiastically announced at Council meeting: "If that's where the payroll tax money goes, I'm all for it!"

. . . the paving crews nibbled away at Maumee's street problem . . .

. . . until, today, this Ohio city can boast of the finest streets in the state

BLACK BEAUTY

New York's Taconic Parkway Extended with Asphalt Paving

NEW YORK'S Taconic Parkway penetrates the Hudson Valley like a surgeon's incision, laying open the historic country of the old Dutch patroons. In the 1700's, this same route was traveled by Rogers' Rangers as they fled south from Ticonderoga.

Today, the direction of flight has been reversed as New Yorkers flee the masonry canyons of Manhattan on weekends via the Taconic Parkway. And history of another sort is being written. Last year the Taconic State Parkway Commission broke with Empire State habit to specify asphalt paving for an eight-mile extension of the parkway in Columbia County. And present plans are to asphalt-pave an additional twelve miles in 1960 to connect with the Berkshire Spur of the New York Thruway.

The 1958 construction consisted of a pavement structure twenty inches in thickness. These included eight inches of asphalt-penetrated macadam base on nine inches of native gravel, topped off with three inches of asphalt-concrete binder and wearing courses. Designed for passenger cars only, like all parkways, the Taconic is a double-barreled highway with 24-foot-wide roadways.

Symbols of sound construction are these rollers concentrated on the Taconic job

Cost of the state's initial asphalt-paved section of parkway was a modest $229,700 per mile. Excellent workmanship featured the construction with close attention given to adequate compaction in every course. Sound performance of this pavement is expected to open the door to a bolder use of asphalt paving in future New York parkway planning.

Thick asphalt mat covers ancient route of conquest

GREAT CAES

The footsore centurion took weeks; today's motorist does it in hours

Italy's New "Highway of the Sun" Recalls the Glory that was Rome's

The Sun Highway will eventually be extended across the waist of Italy to Adriatic shore

AESAR'S GHOST

Italy's New "Highway of the Sun" Recalls the Glory that was Rome's

Italy's new superhighway is part of a spreading worldwide network of modern asphalt-paved roads

IT WOULD be hard to say when the engineering and military professions were joined in wedlock. But it's reasonably safe to say the Caesars built their empire on the plans of their highway engineers.

The Roman legions that marched into Hither Gaul, tramped home again over Roman roads that were the engineering marvels of their time. But for the weary centurion it was a long hike. From Milano to Bologna is 150 aching miles, and the Roman traveler measured the journey in terms of weeks.

Today the same mileage can be clipped off in 150 minutes by the heavy-footed motorist who wants to take full advantage of the world's first controlled-access speedway—the "Sun Highway."

POSTED FOR 100 MPH

The Milan-Bologna superhighway, opened this year, is the first leg of a 460-mile asphalt-paved beauty that will link up Milan, Bologna, Rome and Naples. Built to accommodate the Ferrari fanciers, the road is posted for 100-mph speeds. This is 30-mph above the highest posted speed limit on any American turnpike.

Ultimately, the "Sun Highway" will cut across the Italian peninsula from Naples to Bari on the Adriatic coast, then on down to the heel of the boot and a ferry connection with Albania and Greece.

In most respects, the new Italian superhighway measures up to the specifications for an American Interstate project. It's a four-lane divided highway with a landscaped median. Each roadway is 24.6 feet wide, with eight-foot paved shoulders.

ASPHALT STABILIZED BASE

A special feature of the construction is the use of asphalt stabilized base, or "misto naturale stabilizzato a bitume." Our Italian correspondent advises us that Italy, like Germany, is turning more and more to this type of base construction because it permits wider use of low-cost local materials, it allows full mechanization of the work, and assures a sound performance by the surface pavement under traffic.

The seven inches of asphalt stabilized base is used alternatively with ten inches of asphalt penetrated macadam. Either type base is placed on 14 inches of mechanically mixed mate-

rial. Levelling and wearing courses total about three inches of hot plant mix, fully compacted.

ELECTRONIC PAVING CONTROLS

An interesting variation is the use of optical instrument guides to control the finished longitudinal profile of the pavement. This device consists of an electronic "eye" mounted on the asphalt spreader. This "eye" is focused on another optical instrument set on a tripod ahead of the paving machine. This "line of vision" establishes the perfect gradient line and any deviation from this line automatically is corrected by the machine.

Paving machines on the Sun Highway were literally "on the beam"—an electronic device that assures the smoothest of asphalt-smooth rides

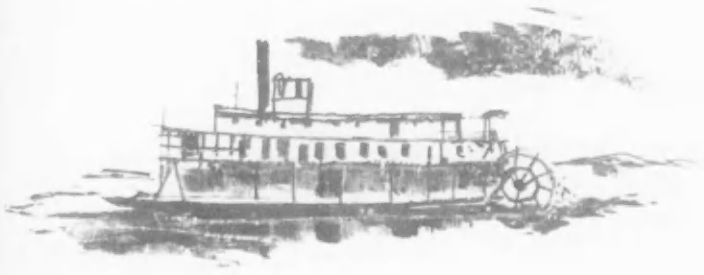
The 185-billion lire "Sun Highway" is only one of several important road-building projects moving ahead in Italy, all modern asphalt pavements. These include the Brescia-Padova highway, Serravalle, Milan highway, and those between Savona and Ceva, Turin and Ivrea, Genoa and Serravalle (widening of the present highway) and the road between Florence and the sea.

Completion of the "Sun Highway" is expected before 1963, all the way from Milan across the Apennines to sunny Napoli. Then Italian travelers can tromp on the gas pedal and murmur, with Virgil:

"Easy is the descent to Avernus. . ."

Super-smooth pavement is designed for speeds of 100 miles per hour

THE NATCHEZ TRACE



MILE after asphalt-paved mile, the historic "Notchey Trace" is being restored after a full century of eclipse.

For a period of about three decades at the opening of the 19th century, this old Indian trail served as the only overland link with the Mississippi country. It echoed to the tread of American militiamen returning from the successful defense of New Orleans in 1815, and to the roistering of wild Kentuck flatboatmen, bound home to the Ohio after poling their way down the Mississippi. And somewhere in its murky, magnolia-scented depths lies buried the mystery of how Meriwether Lewis, of Lewis-and-Clark fame, met his death.

STEAMBOAT DID IT IN

Oddly, the Trace, which owes its revival to the gasoline engine, was destroyed by the steam engine.

Developed in part as a military road, its economic justification as one of the earliest Federal-aid road projects was its importance as a post road. But it took the postal courier about 24 days to cover the 450 winding miles from Nashville to Natchez, and the Postmaster General began surveying a more direct route to New Orleans, through Georgia.

As far as Mobile, this alternate route was easy traveling, but from there to New Orleans it was heavy going. It was the advent of the steamboat and the establishment of regular service between Mobile and New Orleans, cutting ten days off the travel time, that sounded the death knell of the Trace as a Federal-aid project. Similarly, the appearance of the steamboat on the Mississippi, able to retrace its route upstream, meant the end of the flatboat days and the overland trek back to the Ohio.

MORE THAN 100 MILES PAVED

The Natchez Trace sank back into the weeds and scrub growth and became virtually obliterated until a quarter of a century ago when the first appropriation was made to resurrect the old Trace as a national parkway. Today nearly 150 miles, principally between Jackson and Tupelo in Mississippi, are paved and more than 100 additional miles are graded and ready for paving as funds become available.

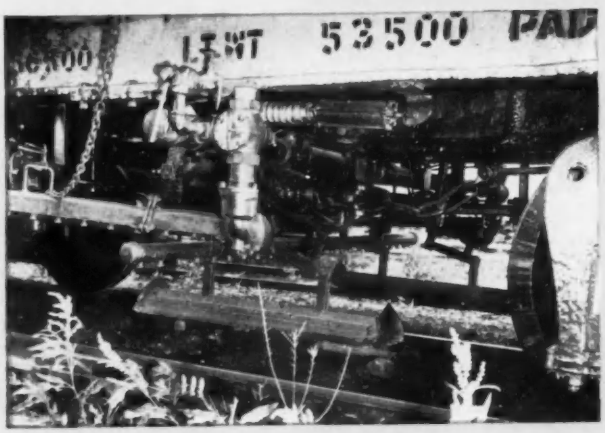
As a parkway it is out-of-bounds to trucks and the structural design of the parkway is standard throughout: two inches of asphalt concrete on eight inches of gravel base. Pavement width is 22 feet with six-inch turf shoulders on each side of the roadway. Construction is proceeding at an accelerated pace, steadily opening up to the American vacation traveler, a country rich in lore and legend.

WE'VE BEEN WORKIN' ON THE RAILROAD

Above: The hot asphalt is sprayed on the railroad ballast

Center: The roadbed after application of the hot asphalt spray

Below: Special shoes protect the rails during asphalt application



Asphalt-Treated Ballast Promises Re

SOME 23 miles of the Santa Fe mainline have a new look this summer, and the critical eyes of the railroad world are focused on this new adventure in asphalt technology.

It could mean annual maintenance-of-way savings running well into the millions of dollars.

Asphalt-treated railroad ballast is not exactly a new concept. It has been the subject of considerable hard-headed thinking by railroad engineers and asphalt technologists for more than two decades. As early as 1943 a short experimental stretch of track on the Illinois Central Railroad was treated, using jerry-built equipment. Treatment consisted of a penetration application of hot asphalt cement on the ties and ballast stone, followed by a spread of cover stone.

SPECIAL EQUIPMENT BUILT

For more than ten years the Illinois Central project was observed and the beneficial results calculated. These could be measured in terms of longer life for the ties and a sharp reduction in man-hours of labor required for ballast maintenance. Based on calculations made by Asphalt Institute observers, it was estimated that asphalt treatment could be translated into savings of more than $1,000 per mile annually on the nation's 250,000 miles of Class I railroad trackage.

With funds made available by the Institute and the Association of American Railroads, two unique pieces of experimental rolling stock were developed. These consisted of a specially designed asphalt distributor built on a railroad flat car and a bottom-dump hopper car modified to control aggregate spreading. These units were completed last spring and offered to the railroads on a free-loan basis under terms of an agreement between the Association of American Railroads and The Asphalt Institute.

The hot asphalt cement is fed to the distributor from insulated tank cars which transport the asphalt directly from the refinery. A spray bar is mounted beneath the distributor car with retractable outrigger spray bars on each side of the car. The car also is equipped with a pump, a hot oil system for maintaining heated supply lines, and a tachometer for governing the rate of asphalt application. The aggregate spreading car is a conventional bottom-dump hopper car of 50-ton capacity with specially designed equipment mounted beneath the bottom openings to control the spread at a uniform rate.

SANTA FE TAKES THE LEAD

First to avail itself of the new equipment was the Santa Fe System whose chief engineer, Mr. R. H. Beeder, designated six experimental sections in California, Arizona, New Mexico, Missouri, Kansas and Illinois. An Eastern road has expressed an interest in borrowing the equipment for experimental treatment of several timber bridges this summer.

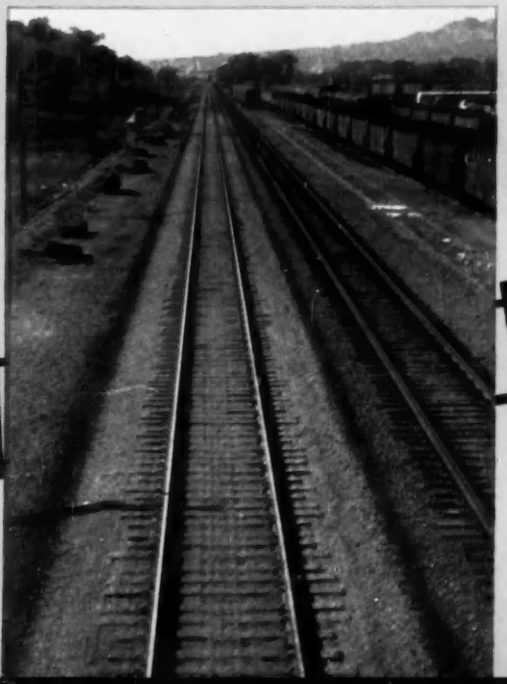
Asphalt is applied at a rate of 1 to 2 gallons per square yard depending on the open-ness of the ballast, and penetrates into the stone to a depth of about two inches or more. The cover aggregate, applied at a rate of 15-25 pounds per square yard, as required, serves as a blotter course and aids in obtaining an impervious surface seal.

The treatment compares in many respects with the seal coating of highway pavements. It minimizes the infiltration of surface water into the ballast and prevents ballast fouling from dust and debris. This results in better preservation of the ballast foundation and reduced tie-pumping. Similarly, the protective cover of asphalt and aggregate reduces checking and splitting of cross ties as a result of alternate cycles of wetting and drying and, in northern latitudes, freezing and thawing.

The rate of treatment with the present, experimental equipment is limited by the capacity of the asphalt pump, which is one gallon per square yard at a speed of two miles per hour. Greater rates presently require that either the train speed be reduced or a double application be made. Future equipment may overcome this limitation by increasing the pump capacity or employing tandem distributor cars.

Cover aggregate is spread directly behind the asphalt distributor

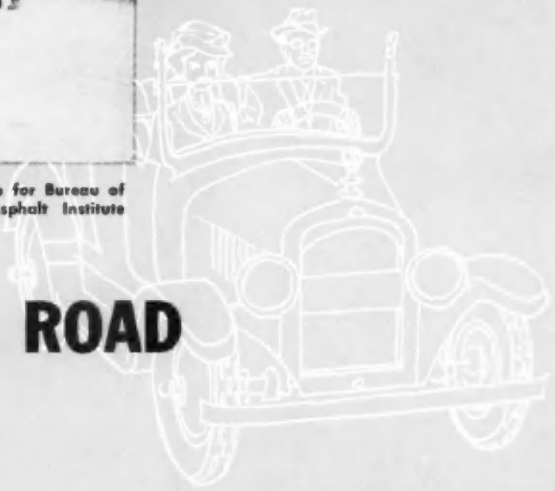
The completed job; untreated section of track at right



ises Reduced Maintenance-of-Way Costs

Bernard E. Gray (center) watchdogged the job for Bureau of Public Roads; later became president of Asphalt Institute

41-Year-Old Pavement Still Giving Service



THE RONCEVERT ROAD

WEST VIRGINIA is not a large state, as states go. But its people argue, with some justification, that if it could be rolled out flat it would be larger than Texas.

Because it's built on a vertical plane, rather than horizontal, West Virginia isn't normally considered an agricultural state. But its valleys are rich and fruitful and Greenbrier County, crowding the Virginia line, is a busy agrarian community.

So, when Congress in 1916 passed the first Federal-Aid road act to bring the American farmer to market, West Virginia promptly designated as its first project the 2½ mile road from Lewisburg to the Chesapeake & Ohio railhead at Roncevert. Asphalt-paved, the project was completed in the summer of 1918 and today, 41 years later, much of the original pavement is still in service with little evidence of deterioration.

WATERBOUND MACADAM BASE

An old waterbound macadam pavement served as the base for a two-inch asphalt mat. The macadam base was worn and washed in places, but it rested on a good foundation and it was supplemented by good quality stone which also was readily available for the asphalt mixture.

In 1936 it was decided to widen the old pavement from 14 feet to twenty feet and to eliminate three dangerous curves. This was done, employing an eight-inch base with two inches of asphalt concrete for the new pavement. Nothing was done to the old pavement except for a light surface treatment to renew the surface and give a uniform appearance to the wider pavement.

The road today is part of the proposed system of "main county roads" in the state. In addition to serving local farm traffic, it also accommodates through traffic moving between the upper and lower ends of the state, through into Virginia and points South. Upwards of 500 vehicles travel the road daily, 65 percent of them automobiles, and the rest mainly light farm trucks.

For West Virginia, the remarkable service record of the Roncevert-Lewisburg road is an object lesson which could profitably be studied by officials charged with the responsibility of rebuilding a creaking highway system.

THE ASPHALT INSTITUTE

EXECUTIVE OFFICES AND LABORATORIES

Asphalt Institute Building
Campus—University of Maryland
College Park, Maryland

MEMBERS OF THE ASPHALT INSTITUTE

(As of June 1, 1959)

The Asphalt Institute is an international, nonprofit association sponsored by members of the petroleum asphalt industry to serve both users and producers of asphaltic materials through programs of engineering service, research and education. Membership is limited to refiners of asphalt from crude petroleum. Institute members provide quality products and advocate good quality construction and timely maintenance.

ALLIED MATERIALS CORPORATION
Oklahoma City, Oklahoma

AMERICAN BITUMULS & ASPHALT COMPANY
San Francisco, California
Baltimore, Maryland

AMERICAN PETROFINA COMPANY OF TEXAS
Dallas, Texas

ANDERSON-PRICHARD OIL CORPORATION
Oklahoma City, Oklahoma

ASHLAND OIL & REFINING COMPANY
Ashland, Kentucky

THE ATLANTIC REFINING COMPANY
Philadelphia, Pennsylvania

BERRY ASPHALT COMPANY
Magnolia, Arkansas

BERRY REFINING COMPANY
Chicago, Illinois

BRITISH AMERICAN OIL CO. LTD.
Toronto, Ontario, Canada

BRITISH PETROLEUM COMPANY LTD.
London, England

BYERLYTE CORPORATION
Cleveland, Ohio

CANADIAN HUSKY OIL LIMITED
Calgary, Alberta, Canada

THE CARTER OIL COMPANY
Billings, Montana

CITIES SERVICE OIL COMPANY (PA.)
New York, N. Y.

COSDEN PETROLEUM CORPORATION
Big Spring, Texas

DERBY REFINING COMPANY
Division of Colorado Oil and Gas Co.
Wichita, Kansas

DOUGLAS OIL CO. OF CALIFORNIA
Los Angeles, California

D-X SUNRAY OIL COMPANY
Tulsa, Oklahoma

EDGINGTON OIL REFINERIES, INC.
Long Beach, California

EMPIRE PETROLEUM COMPANY
Denver, Colorado
Sheboygan, Wisconsin

EMPIRE STATE OIL COMPANY
Thermopolis, Wyoming

ESSO STANDARD OIL COMPANY
New York, N. Y.

FARMERS UNION CENTRAL EXCHANGE, INC.
Billings, Montana

GENERAL ASPHALTS, INC
A subsidiary of Kerr-McGee Oil Industries, Inc.
Oklahoma City, Oklahoma

GOLDEN BEAR OIL COMPANY
Los Angeles, California

GREAT NORTHERN OIL CO.
St. Paul, Minnesota

HUNT OIL COMPANY
Dallas, Texas

HUSKY OIL COMPANY
Cody, Wyoming

IMPERIAL OIL LIMITED
Toronto, Ontario, Canada

LEONARD REFINERIES, INC.
Alma, Michigan

LION OIL COMPANY
A Division of Monsanto Chemical Company
El Dorado, Arkansas

MACMILLAN PETROLEUM CORPORATION
El Dorado, Arkansas
Los Angeles, California

MALCO REFINERIES, INC.
Roswell, New Mexico

MARUZEN OIL COMPANY LIMITED
Osaka, Japan

MOBIL OIL COMPANY
A Division of Socony Mobil Oil Co., Inc.
New York, N. Y.

MONARCH REFINERIES, INC.
Oklahoma City, Oklahoma

NORTHWESTERN REFINING COMPANY
St. Paul Park, Minnesota

A. B. NYNAS-PETROLEUM
Nynashamn, Sweden

PAZ OIL AND TRADING COMPANY LTD.
Haifa, Israel

PHILLIPS PETROLEUM COMPANY
Bartlesville, Oklahoma

RAFFINERIE BELGE DE PETROLES, S.A.
Antwerp, Belgium

RICHFIELD OIL CORPORATION
Los Angeles, California

JEFF P. ROYDER
Houston, Texas

SHELL OIL COMPANY
New York, N. Y.
San Francisco, California

SHELL OIL COMPANY OF CANADA, LTD.
Toronto, Ontario, Canada

SHELL PETROLEUM COMPANY, LTD.
London, England

SINCLAIR REFINING COMPANY
New York, N. Y.

SOUTH AFRICAN TORBANITE MINING AND REFINING CO. LTD.
Boksburg North, Transvaal

THE SOUTHLAND COMPANY
Yazoo City, Mississippi

STANDARD OIL COMPANY OF BRITISH COLUMBIA, LTD.
Vancouver, B. C., Canada

THE STANDARD OIL COMPANY
(An Ohio Corporation)
Cleveland, Ohio

SUN OIL COMPANY
Philadelphia, Pennsylvania

UNION OIL COMPANY OF CALIFORNIA
Los Angeles, California

U. S. OIL AND REFINING COMPANY
Los Angeles, California

WILSHIRE OIL COMPANY OF CALIFORNIA
Los Angeles, California

WITCO CHEMICAL COMPANY, INC.
Pioneer Products Division
New York, N. Y.

INSTITUTE ENGINEERING OFFICES

(As of June 1, 1959)

DIVISION I—ATLANTIC-GULF

NEW YORK 20, N. Y.—1270 Avenue of the Americas
New York City, Long Island and New Jersey

BOSTON 16, MASSACHUSETTS—419 Boylston Street
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont

ALBANY 7, NEW YORK—11 North Pearl Street
New York State (except New York City and Long Island)

HARRISBURG, PENNSYLVANIA—800 North Second Street
Delaware, Pennsylvania

RICHMOND 19, VIRGINIA—Travelers Building
District of Columbia, Maryland, North Carolina, Virginia

ATLANTA 9, GEORGIA—881 Peachtree Street, N.E.
Florida, Georgia, South Carolina

MONTGOMERY 4, ALABAMA—79 Commerce Street
Alabama, Tennessee

NEW ORLEANS 18, LOUISIANA—Maison Blanche Building
Louisiana, Mississippi

DIVISION II—OHIO VALLEY-GREAT LAKES

COLUMBUS 15, OHIO—Neil House
Indiana, Kentucky, Michigan, Ohio, West Virginia

LANSING 16, MICHIGAN—109 West Michigan Avenue
Michigan, Northern Indiana

LOUISVILLE 7, KENTUCKY—4050 Westport Road
Kentucky, Southern Indiana

DIVISION III—MIDWEST

ST. PAUL 4, MINNESOTA—1951 University Ave.
Colorado, Illinois, Iowa, Idaho, Kansas, Minnesota, Montana, Missouri, Nebraska, North Dakota, South Dakota, Utah, Wisconsin, Wyoming

PIERRE, SOUTH DAKOTA—104 South Euclid
North Dakota and South Dakota

CHICAGO 39, ILLINOIS—6261 West Grand Avenue
Wisconsin and Metropolitan Chicago

SPRINGFIELD, ILLINOIS—2606½ South Sixth Street
Illinois (except Metropolitan Chicago)

KANSAS CITY 3, KANSAS—2500 Johnson Drive
Kansas, Missouri, Eastern Nebraska

DENVER 2, COLORADO—1031 15th Street
Colorado, Western Nebraska, Utah, Wyoming

HELENA, MONTANA
Montana and Idaho

DIVISION IV—SOUTHWEST

DALLAS 6, TEXAS—Meadows Building
Arkansas, New Mexico, Oklahoma, Texas

AUSTIN 1, TEXAS—Perry-Brooks Building
Texas

OKLAHOMA CITY 2, OKLAHOMA—Republic Building
Arkansas, Oklahoma

SANTA FE, NEW MEXICO—10 Radio Plaza
New Mexico, Western Texas

DIVISION V—PACIFIC COAST

BERKELEY 10, CALIFORNIA—810 University Ave.
Alaska, Arizona, California, Nevada, Oregon, Washington

LOS ANGELES 17, CALIFORNIA—1709 West 8th St.
Arizona, Southern California

SEATTLE 1, WASHINGTON — White-Henry-Stuart Building
Alaska, Washington

SACRAMENTO 14, CALIFORNIA—Forum Building
Central California, Northern California, Nevada

PORTLAND 1, OREGON—2035 S.W. 58th Avenue
Oregon

Printed in the U.S.A.